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## SPECIFICATION

## Title of the Invention

## MULTIBAND DIPLEXER CIRCUIT

5

1. A multiband diplexer circuit comprising:  
a single-pole-dual-through switch;  
a first unbalanced-input-balanced-output bandpass filter connected  
to a first output port of said first switch;

10

a second unbalanced-input-balanced-output bandpass filter  
connected to a second output port of said switch;

a second dual-pole-single-through switch connected to one of  
balanced output ports of said first bandpass filter and one of balanced  
output ports of said second bandpass filter;

15

a third dual-pole-single-through switch connected to the other of  
balanced output ports of said first bandpass filter and the other of balanced  
output ports of said second pass band filter;

said first to third high-frequency switches being switched depending on a  
passing high-frequency signal,

20

whereby an unbalanced high-frequency signal input into said first  
switch is output from said output ports of said second and third switches as  
a balanced high frequency signal.

2. The multiband diplexer circuit according to claim 1, wherein said  
first and second band filters have different transmitting frequency bands to  
each other.

25

3. A multiband diplexer circuit comprising:  
a first unbalanced-input-balanced-output bandpass filter;  
a second unbalanced-input-balanced-output bandpass filter having a  
different transmitting frequency band from said first bandpass filter;

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a first phase shifter connected to an unbalanced input port of said first bandpass filter;

a second phase shifter connected to an unbalanced input port of said second bandpass filter;

5 a third phase shifter connected to one of balanced output ports of said first bandpass filter;

a fourth phase shifter connected to the other of balanced output ports of said first bandpass filter;

a fifth phase shifter connected to one of balanced output ports of  
10 said second bandpass filter;

a sixth phase shifter connected to the other of balanced output ports of said second bandpass filter;

connecting in parallel one of said phase shifters connected to said first bandpass filter and one of said phase shifters connected to said second  
15 bandpass filter so as to connect to a first output port;  
connecting in parallel the other of said phase shifters connected to said first bandpass filter and the other of said phase shifters connected to said second bandpass filter so as to connect to a second output port,  
connecting in parallel said first and second phase shifters so as to connect  
20 to an input port,

connecting said first, third and fourth phase shifters to said first bandpass filter so that impedance is high in the transmitting frequency band of said second bandpass filter, and  
connecting said second, fifth and six phase shifters to said second bandpass  
25 filter so that impedance is high in the transmitting frequency band of said first bandpass filter,

whereby an unbalanced high-frequency signal input into an input port is output from said first and second output ports as a balanced

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high-frequency signal.

4. A multiband diplexer circuit comprising:
- a first single-pole-dual-through switch;
  - a first unbalanced-input-balanced-output bandpass filter connected
  - 5 to a first output port of said first switch;
  - a second unbalanced-input-balanced-output bandpass filter
  - connected to a second output port of said switch;
  - a third phase shifter connected to one of balanced output ports of
  - said first bandpass filter,
  - 10 a fourth phase shifter connected to the other of balanced output ports
  - of said first bandpass filter,
  - a fifth phase shifter connected to one of balanced output ports of
  - said second bandpass filter,
  - a sixth phase shifter connected to the other of balanced output ports
  - 15 of said second bandpass filter,
  - connecting in parallel one of said phase shifters connected to said first
  - bandpass filter and one of said phase shifters connected to said second
  - bandpass filter so as to connect to a first output terminal,
  - connecting in parallel the other of said phase shifters connected to said first
  - 20 bandpass filter and the other of said phase shifters connected to said second
  - bandpass filter so as to connect to a second output port,
  - connecting said third and fourth phase shifters to said first bandpass filter
  - so that impedance is high in the transmitting frequency band of said second
  - bandpass filter,
  - 25 connecting said fifth and sixth phase shifters to said second bandpass filter
  - so that impedance is high in the transmitting frequency band of said first
  - bandpass filter, and
  - said first switch being switched depending on a passing high-frequency

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signal,

whereby an unbalanced high-frequency signal input into said first switch is output from said first and second output ports as a balanced high-frequency signal.

- 5 5. A multiband diplexer circuit comprising:
- a first unbalanced-input-balanced-output bandpass filter;
  - a second unbalanced-input-balanced-output bandpass filter having a different transmitting frequency band from said first bandpass filter;
  - a first phase shifter connected to an unbalanced-input port of said
  - 10 first bandpass filter;
  - a second phase shifter connected to an unbalanced-input port of said second bandpass filter;
  - a second dual-pole-single-through switch connected to one of balanced-output ports of said first bandpass filter and one of
  - 15 balanced-output ports of said second bandpass filter;
  - a third dual-pole-single-through switch connected to the other of balanced-output ports of said first bandpass filter and the other of balanced-output ports of said second bandpass filter;
  - connecting in parallel said first and second phase shifters so as to connect
  - 20 to an input port,
  - connecting said first phase shifter to said first bandpass filter so that impedance is high in the transmitting frequency band of said second bandpass filter,
  - connecting said second phase shifter to said second bandpass filter so that
  - 25 impedance is high in the transmitting frequency band of said first bandpass filter, and
  - said second and third switches being switched depending on a passing high-frequency signal,

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whereby an unbalanced high-frequency signal input into an input port is output from the second and third output ports as a balanced high-frequency signal.

6. The multiband diplexer circuit according to any one of claims 1 to 5,  
5 wherein said first and second unbalanced-balanced bandpass filters have different input impedance  $Z_i$  and output impedance  $Z_o$ , and the output impedance  $Z_o$  is larger than the input impedance  $Z_i$ .
7. The multiband diplexer circuit according to any one of claims 1 to 6, wherein said bandpass filter is a SAW filter.
- 10 8. A multiband diplexer circuit, wherein at least part of said multiband filter circuit recited in any one of claims 1 to 7 is constituted by electrode patterns formed on ceramic substrates and bandpass filters either mounted on ceramic substrates or formed by electrode patterns on said ceramic substrates.
- 15 9. A multiband mobile phone comprising a high-frequency circuit comprising the multiband diplexer circuit recited in any one of claims 1-7.



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**DETAILED DESCRIPTION OF THE INVENTION**

[0001]

**Field of the Invention**

The present invention relates to an unbalanced-balanced multiband  
5 diplexer circuit usable in RF circuits for multiband communications  
devices such as mobile phones, etc. that can be used in different access  
systems.

[0002]

**Prior Art**

10 There are various access systems in mobile phones in the world,  
and pluralities of access systems are simultaneously used in the same areas.  
One of the access systems mainly used at present is, for instance, a TDMA  
(Time Division Multiple Access) system. Main communications systems  
using this TDMA system include PDC (Personal Digital Cellular) in Japan,  
15 GSM (Global System for Mobile Communications) and DCS1800 (Digital  
Cellular System 1800) mainly used in Europe, PCS (Personal  
Communications Service) mainly used in the U.S. etc.

[0003]

Another access system that has recently become popular in the U.S.  
20 and Korea is a CDMA (Code Division Multiple Access) system. IS-95  
(Interim Standard-95) is mainly used in the U.S. as a typical standard in the  
frequency band of PCS (Personal Communications Service). In addition,  
W-CDMA (Wideband CDMA), a third-generation communications system,  
which can achieve high-speed data transmission, has been put into practical  
25 use.

[0004]

Conventional mobile phones are designed for one communications  
system, for instance, GSM. However, because of recent increase in the

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number of users and for the convenience of users, pluralities of communications or access systems applicable to dual-band or triple-band mobile phones were proposed, and there is also demand to quatro-band mobile phones. If high-frequency parts were simply mounted in every  
5 communications systems in the high-frequency circuits of such multiband mobile phones, the high-frequency circuits would be inevitably large. For miniaturization, common high-frequency parts have been used more and more in different communications systems. One example thereof is a diplexer circuit comprising a common high-frequency part for different  
10 communications systems. For instance, Patent Literature 1 discloses a two-frequency diplexer 200 having passbands of 950 MHz and 1.9 GHz, which comprises bandpass filters 20a, 20b and phase shifters 40a, 40b, 70a, 70b, as shown in the equivalent circuit of Fig. 7.

[0005]

15 [Patent Literature 1] Japanese Patent Laid-Open No. 8-321738

[0006]

**Problems to be solved by the Invention**

However, it has been found that the use of such a diplexer circuit for the high-frequency circuits of multiband mobile phones causes several  
20 problems. A high-frequency circuit for a multiband mobile phone is constituted by conventional diplexer circuit 200 in a transmitting circuit and a receiving circuit, as shown in Fig. 8. Fig. 8 shows a high-frequency circuit for a dual-band mobile phone applicable to two communications systems of GSM850 (transmitting frequency: 824-849 MHz, receiving  
25 frequency: 869-894 MHz) and GSM900 (transmitting frequency: 880-915 MHz, receiving frequency: 925-960 MHz).

To reduce a noise index and increase a receiving sensitivity, the receiving circuit comprises balanced high-frequency parts (low-noise

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amplifier 266, mixer 268, etc.) comprising two signal lines. Accordingly, the connection of said high-frequency parts to a low-noise amplifier needs a balanced-to-unbalanced transformer. In addition, the input impedance of said low-noise amplifier 266 is set at about 50 to 300  $\Omega$ , needing an  
5 impedance conversion circuit. It is thus considered to use balanced-to-unbalanced transformers (baluns) 262, 263 as circuit elements having the functions of a balanced-to-unbalanced transformer and an impedance conversion circuit. However, this increases the number of circuit elements in the high-frequency circuit, and an insertion loss of about  
10 1 dB is added from the balun in a frequency band of the operating high-frequency signal. As a result, to obtain a desired gain in the low-noise amplifier 266, an excess bias current should be added to the amplifying element, resulting in increase in the battery consumption of mobile phones.

15 [0007]

In a high-frequency circuit of a TDMA system, the switching of connection between an antenna 269 and transmitting/receiving circuits is generally conducted by a switch circuit 264. In this switch circuit 264, GaAs FETs and diodes are used as switching elements. In such switch  
20 circuit, a high-frequency signal leaks to the level of about 20-30 dB (isolation) between the transmitting circuit and the receiving circuit. Accordingly, there is the leak of a high-frequency signal to the other circuits, if slightly.

For instance, when extremely close frequency bands are used in  
25 different communications systems, for instance, of GSM850 and GSM900, or DCS1800 and PCS, a receiving frequency band and a transmitting frequency band partially overlap. When communications are carried out by GSM900, for instance, part of the high-frequency signal is leaked from

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the transmitting circuit to the receiving circuit via a switch circuit, and  
input into the low-noise amplifier 266 via a bandpass filter 252 handling  
the receiving signal of GSM850. Also, when communications are carried  
out by GSM850, the receiving signal of GSM850 from the antenna is input  
5 into the amplifier 265 via a bandpass filter 251 handling the transmitting  
signal of GSM900. In any case, the communications quality is  
deteriorated.

[0008]

Thus, the present invention has been carried out to solve at least one  
10 of these problems. Accordingly, the first object of the present invention is  
to provide an unbalanced-balanced multiband diplexer circuit with  
suppressed increase in insertion loss, and the second object of the present  
invention is to provide a balanced-unbalanced multiband diplexer circuit,  
which in an application to access systems using extremely close frequency  
15 bands, permits a high-frequency signal in one access system to pass while  
cutting a high-frequency signal in the other access system.

[0009]

**Means for solving the Problems**

The first embodiment of the present invention is a multiband  
20 diplexer circuit comprising:  
a first single-pole-dual-through switch;  
a first unbalanced-input-balanced-output bandpass filter connected  
to a first output port of the first switch;  
a second unbalanced-input-balanced-output bandpass filter  
25 connected to a second output port of the switch;  
a second dual-pole-single-through switch connected to one of  
balanced output ports of the first bandpass filter and one of balanced output  
ports of the second bandpass filter;

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a third dual-pole-single-through switch connected to the other of balanced output ports of the first bandpass filter and the other of balanced output port of the second pass band filter;  
the first to third high-frequency switches being switched depending on a  
5 passing high-frequency signal,

whereby an unbalanced high-frequency signal input into the first switch is output from the output ports of the second and third switches as a balanced high frequency signal.

[0010]

10 In this embodiment, the first and second band filters have different transmitting frequency bands to each other.

[0011]

The second embodiment of the present invention is a multiband diplexer circuit comprising:

- 15 a first unbalanced-input-balanced-output bandpass filter;  
a second unbalanced-input-balanced-output bandpass filter having a different transmitting frequency band from the first bandpass filter;  
a first phase shifter connected to an unbalanced input port of the first bandpass filter;  
20 a second phase shifter connected to an unbalanced input port of the second bandpass filter;  
a third phase shifter connected to one of balanced output ports of the first bandpass filter;  
a fourth phase shifter connected to the other of balanced output  
25 ports of the first bandpass filter;  
a fifth phase shifter connected to one of balanced output ports of the second bandpass filter;  
a sixth phase shifter connected to the other of balanced output ports

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- of the second bandpass filter;  
connecting in parallel one of the phase shifters connected to the first  
bandpass filter and one of the phase shifters connected to the second  
bandpass filter so as to connect to a first output port;  
5 connecting in parallel the other of the phase shifters connected to the first  
bandpass filter and the other of the phase shifters connected to the second  
bandpass filter so as to connect to a second output port,  
connecting in parallel the first and second phase shifters so as to connect to  
an input port,  
10 connecting the first, third and fourth phase shifters to the first bandpass  
filter so that impedance is high in the transmitting frequency band of the  
second bandpass filter, and  
connecting the second, fifth and six phase shifters to the second bandpass  
filter so that impedance is high in the transmitting frequency band of the  
15 first bandpass filter,  
whereby an unbalanced high-frequency signal input into an input  
port is output from the first and second output ports as a balanced  
high-frequency signal.

[0012]

- 20 The third embodiment of the present invention is a multiband  
diplexer circuit comprising:  
a first single-pole-dual-through switch;  
a first unbalanced-input-balanced-output bandpass filter connected  
to a first output port of the first switch;  
25 a second unbalanced-input-balanced-output bandpass filter  
connected to a second output port of the switch;  
a third phase shifter connected to one of balanced output ports of  
the first bandpass filter,

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a forth phase shifter connected to the other of balanced output ports of the first bandpass filter,

a fifth phase shifter connected to one of balanced output ports of the second bandpass filter,

5 a sixth phase shifter connected to the other of balanced output ports of the second bandpass filter,

connecting in parallel one of the phase shifters connected to the first bandpass filter and one of the phase shifters connected to the second bandpass filter so as to connect to a first output port,

10 connecting in parallel the other of the phase shifters connected to the first bandpass filter and the other of the phase shifters connected to the second bandpass filter so as to connect to a second output port,

connecting the third and fourth phase shifters to the first bandpass filter so that impedance is high in the transmitting frequency band of the second

15 bandpass filter,

connecting the fifth and sixth phase shifters to the second bandpass filter so that impedance is high in the transmitting frequency band of the first bandpass filter, and

20 the first switch being switched depending on a passing high-frequency signal,

whereby an unbalanced high-frequency signal input into the first switch is output from the second output port as a balanced high-frequency signal.

[0013]

25 The [third] fourth embodiment of the present invention is a multiband diplexer circuit comprising:

a first unbalanced-input-balanced-output bandpass filter;

a second unbalanced-input-balanced-output bandpass filter having a

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different transmitting frequency band from the first bandpass filter;

a first phase shifter connected to an unbalanced-input port of the first bandpass filter;

5 a second phase shifter connected to an unbalanced-input port of the second bandpass filter;

a second dual-pole-single-through switch connected to one of balanced-output ports of the first bandpass filter and one of balanced-output ports of the second bandpass filter;

10 a third dual-pole-single-through switch connected to the other of balanced-output ports of the first bandpass filter and the other of balanced-output ports of the second bandpass filter;

connecting in parallel the first and second phase shifters so as to connect to said input port,

connecting said second phase shifter to the second bandpass filter so that  
15 impedance is high in the transmitting frequency band of the first bandpass filter, and

the second and third switches being switched depending on a passing high-frequency signal,

whereby an unbalanced high-frequency signal input into an input  
20 port is output from the second and third output ports as a balanced high-frequency signal.

[0014]

In the first to fourth embodiments, the first and second unbalanced-balanced bandpass filters have different input impedance  $Z_i$   
25 and output impedance  $Z_o$ , and the output impedance  $Z_o$  is preferably larger than the input impedance  $Z_i$ . Also, although the bandpass filter may be constituted by an LC circuit, it is preferably a SAW (surface acoustic wave) filter.



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[0015]

The fifth embodiment of the present invention is a multiband diplexer circuit, wherein at least part of the multiband diplexer circuit recited in the first to fourth embodiments is constituted by electrode patterns formed on ceramic substrates and bandpass filters either mounted on ceramic substrates or formed by electrode patterns on the ceramic substrates. In this multiband diplexer circuit, other high-frequency parts except for the multiband diplexer circuit such as a high-frequency switch in the antenna top, filters, amplifiers, etc., may also be formed integrally in the ceramic substrates.

[0016]

The sixth embodiment of the present invention is a multiband mobile phone comprising a high-frequency circuit comprising any one of the first to fourth embodiments.

[0017]

**Mode for carrying out the Invention****(Example 1)**

Fig. 1 shows one embodiment as to a multiband diplexer circuit 1 of the present invention. This multiband diplexer circuit comprises a first single-pole-dual-through switch 10a at an input port, a first unbalanced-input-balanced-output bandpass filter 20a connected to a first output port 100b of the first switch 10a, a second unbalanced-input-balanced-output bandpass filter 20b connected to a second output port 100c of the first switch 10a, a second dual-pole-single-through switch 10b connected to one of balanced output ports 120c of the first bandpass filter 20a and one of balanced output ports 120b of the second bandpass filter 20a, and a third dual-pole-single-through switch 10c connected to the other of balanced output ports 110b of said

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first bandpass filter 20a and the other of balanced output ports 110b of said second pass band filter.

In this embodiment, the bandpass filters 20a, 20b are constituted by unbalanced-balanced SAW filters. The unbalanced-balanced SAW filter  
5 has an impedance conversion function and a balance-unbalance conversion function. The adjustment of the crossing width, arrangement and coupling of electrode fingers makes it have different input and output impedances and conduct balance-unbalance conversion.

The second and third high-frequency switches connected to the  
10 balanced ports are constituted to have substantially the same characteristic impedance as the output impedance of the SAW filters for matching. To adjust the degree of balancing (balance characteristics) of a balanced signal input into or output from the balanced ports, an inductance element may be connected between the balanced ports.

15 [0018]

Figs. 9-13 show examples of the equivalent circuits of the first to third high-frequency switches 10a, 10b, and 10c.

A switch circuit shown in Fig. 9 is a single-pole-dual-through switch comprising a transmission line and a diode as main components.  
20 Specifically, this switch circuit comprises a transmission line LS1 between a contact point 100a and a contact point 100c, and a diode DD1 and a DC-cutting capacitor CS1 between the contact point 100c of the transmission line LS1 and a ground. A control port VC1 is provided between the diode DD1 and the DC-cutting capacitor CS1. The capacitor  
25 CS1 constitutes a series resonance circuit with an inductance component during the operation of the diode DD1, so that it is in a short-circuited state during the operation of the diode DD1. This switch circuit further comprises a diode DD2 series-connected to the diode DD1 via the

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transmission line LS1 between the contact point 100a and the contact point 100b, and a high-frequency choke coil LS2 between the contact point 100b and the ground. The high-frequency choke coil LS2 may be a high-impedance line constituted by a transmission line. The diodes DD1, DD2 are turned ON or OFF by a control voltage supplied from the control port VC1, to switch connection between the contact point 100a and the contact point 100b, and between the contact point 100a and the contact point 100c. Incidentally, each contact point 100a, 100b, 100c is properly provided with a DC-cutting capacitor.

10 [0019]

Figs. 10 and 11 show examples of other switch circuits. As compared with the above, these circuits are different from the former in having a transmission line LS3 in place of the diode DD2. Although the contact point 100b is connected with the bandpass filter 20a or the bandpass filter 20b, the transmission line LS3 is used as a phase shifter and the length thereof is allowed to be high impedance in the transmitting frequency bands of the other bandpass filter. This shifter functions, when viewed the contact point 100b from the contact point 100a, to allow the impedance including the bandpass filter to be a substantially open state (high impedance), thereby adjusting a phase-shifting angle. Thus, in this high-frequency switch, the diode DD2 can be omitted, resulting in decrease in power consumption in the diplexer circuit, and the elimination of the transmission loss of the diode DD2. As the other switch circuits, a GaAs FET may be used as shown in Figs. 12 and 13, thereby enabling various circuits having pluralities of series-connected GaAs FETs.

25 [0020]

The first to third high-frequency switches 20a-20c are properly switched depending on high-frequency signals that should pass, whereby

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an unbalanced high-frequency signal input into the first switch 20a is output from the output ports 130a and 150a of the second and third switches as a balanced high frequency signal. In this embodiment, excellent isolation characteristics are obtained between the bandpass filters  
5 by each high-frequency switch, thereby substantially preventing the high-frequency signal from leaking to the other circuit.

[0021]

(Example 2)

Fig. 2 shows a circuit block of another embodiment as to a  
10 multiband diplexer circuit 1 of the present invention. This multiband diplexer circuit comprises  
a first unbalanced-input-balanced-output bandpass filter 20a,  
a second unbalanced-input-balanced-output bandpass filter 20b  
having a different transmitting frequency band from the first bandpass filter  
15 20a;  
a first phase shifter 40a connected to an unbalanced input port of said first bandpass filter 20a,  
a second phase shifter 40b connected to an unbalanced input port of the second bandpass filter 20b,  
20 a third phase shifter 50a connected to one of balanced output ports 110b of the first bandpass filter 20a,  
a fourth phase shifter 50b connected to the other of balanced output ports 110c of the first bandpass filter 20a,  
a fifth phase shifter 60a connected to one of balanced output ports  
25 of said second bandpass filter 20b,  
a sixth phase shifter 60b connected to the other of balanced output ports of the second bandpass filter 20b,  
connecting in parallel one of the phase shifters 50b connected to the first

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bandpass filter 20a and one of the phase shifters 60a connected to the second bandpass filter 20b so as to connect to a first output port 170a, connecting in parallel the other of the phase shifters 50a connected to the first bandpass filter 20a and the other of the phase shifters 60b connected to the second bandpass filter 20b so as to connect to a second output port 160a, and connecting in parallel the first and second phase shifters so as to connect to the input port 180a.

[0022]

Each phase shifter possesses the same functions as those explained in the previous example, whereby the impedance of a circuit including the bandpass filter is substantially open (high impedance), and can be constituted by transmission lines. As described above, the first, third and fourth phase shifters are connected to the first bandpass filter to provide high impedance in a passband of the second bandpass filter, and the second, fifth and sixth phase shifters are connected to the second bandpass filter to provide high impedance in a passband of the first bandpass filter, thereby dividing the high-frequency signals, so that a unbalanced high-frequency signal input into an input port is output from the first and second outputs as a balanced high-frequency signal.

[0023]

Fig. 3 shows a circuit block of still another embodiment as to a multiband diplexer circuit 1 of the present invention. This multiband diplexer circuit comprises

- a first single-pole-dual-through switch 10a,
- a first unbalanced-input-balanced-output bandpass filter 20a connected to a first output port 100b of the first switch 10a,
- a second unbalanced-input-balanced-output bandpass filter 20b connected to a second output port 100 of the first switch 10a,

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a third phase shifter 50a connected to one of balanced output ports 100b of the first bandpass filter 20a,

a fourth phase shifter 50b connected to the other of balanced output ports 100c of the first bandpass filter 20a,

5 a fifth phase shifter 60a connected to one of balanced output ports 120b of the second bandpass filter 20b,

a sixth phase shifter 60b connected to the other of balanced output ports 120c of the second bandpass filter 20b,

connecting in parallel one of the phase shifters 50b connected to the first  
10 bandpass filter 20a and one of the phase shifters 60a connected to the second bandpass filter 20b so as to connect to a first output port 170a, connecting in parallel the other of the phase shifters 50a connected to the first bandpass filter 20a and the other of the phase shifters 60b connected to the second bandpass filter 20b so as to connect to a second output port  
15 160a,

connecting the third and fourth phase shifters 50a, 50b to the first bandpass filter 20a so that impedance is high in the transmitting frequency band of the second bandpass filter 20b,

connecting the fifth and sixth phase shifters 60a, 60b to the second  
20 bandpass filter 20b so that impedance is high in the transmitting frequency band of the first bandpass filter 20a, and the first switch 10a being switched depending on a passing high-frequency signal, whereby an unbalanced high-frequency signal input into the first switch is output from the first and second output ports 170a, 160a as a  
25 balanced high-frequency signal.

Because each circuit element has the same function as in the above embodiments, its explanation will be omitted. In this embodiment, too, because isolation is secured between the bandpass filters by the

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high-frequency switches and the phase shifters, it is possible to substantially prevent the leak of a high-frequency signal from the other circuit.

[0024]

- 5           Fig. 4 shows a circuit block of still another embodiment as to a multiband diplexer circuit 1 of the present invention. This multiband diplexer circuit comprises a multiband diplexer circuit comprising:
- a first unbalanced-input-balanced-output bandpass filter 20a,
  - a second unbalanced-input-balanced-output bandpass filter 20b
- 10   having a different transmitting frequency band from the first bandpass filter 20a,
- a first phase shifter 40a connected to an unbalanced-input port 110a of the first bandpass filter 40a,
  - a second phase shifter 40b connected to an unbalanced-input port
- 15   120a of the second bandpass filter 20b,
- a second dual-pole-single-through switch 10b connected to one of balanced-output ports 110a of the first bandpass filter 20a and one of balanced-output ports 120b of the second bandpass filter 20b,
  - a third dual-pole-single-through switch 10c connected to the other
- 20   of balanced-output ports 110b of the first bandpass filter 20a and the other of balanced-output ports 120c of the second bandpass filter 20b, connecting in parallel the first and second phase shifters 40a, 40b so as to connect to an input port 180a,
- connecting the first phase shifter 40a to the first bandpass filter 20a so that
- 25   impedance is high in the transmitting frequency band of the second bandpass filter 20b,
- connecting the second phase shifter 40b to the second bandpass filter 20b so that impedance is high in the transmitting frequency band of the first

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bandpass filter 20a, and  
the second and third switches 10b, 10c being switched depending on a  
passing high-frequency signal,

whereby an unbalanced high-frequency signal input into an input  
5 port 180a is output from the second and third output ports 170a, 160a as a  
balanced high-frequency signal.

Because each circuit element has the same function as in the above  
embodiments, its explanation will be omitted. In this embodiment, too,  
because isolation can be secured between the bandpass filters by the  
10 switches, it is possible to substantially prevent the leak of a high-frequency  
signal from the other circuit.

[0025]

Fig. 5 shows a circuit block as to a multiband mobile phone  
comprising a high-frequency circuit comprising the multiband diplexer  
15 circuit comprising still another embodiment of the present invention.

This high-frequency circuit can be used for four different access  
systems of different transmitting/receiving frequencies, GSM850, GSM900,  
DCS1800 and PCS, as shown in Table 1, and the multiband diplexer circuit  
1 is used in the receiving circuit side of an SP5T (Single Pole 5 Throw)  
20 switch shown in Fig.6.



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[0026]

Table 1

Communications Systems	Transmitting Signal Frequency Tx	Receiving Signal Frequency Rx
GSM850	824-849 MHz	869-894 MHz
GSM900	880-915 MHz	925-960 MHz
DCS1800	1710-1785 MHz	1805-1880 MHz
PCS	1850-1910 MHz	1930-1990 MHz

[0027]

- 5           The SP5T switch comprises six input/output terminals;  
a port 510f connected to an antenna ANT,  
a port 510a for inputting the transmitting signals of GSM850 and GSM900,  
a port 510b for inputting the transmitting signals of DCS1800 and PCS,  
a port 510e for outputting the receiving signals of GSM850 and GSM900,  
10 a port 510c for outputting the receiving signal of DCS1800, and  
a port 510d for outputting the receiving signal of PCS,  
a diplexer circuit 550 comprising a lowpass filter for passing the  
high-frequency signals of GSM850 and GSM900 and a highpass filter for  
passing the high-frequency signals of DCS1800 and PCS,  
15 a switch 560 connected to the lowpass filter for switching the connection  
between the transmitting circuits of GSM850 and GSM900 and the  
receiving circuits,  
a switch 570 connected to the highpass filter for switching the connection  
between the transmitting circuits of 1800 and PCS and the receiving  
20 circuits, and  
a switch 580 connected to the switch 570 for switching the connection  
between the receiving circuit of 1800 and the receiving circuit of PCS.

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[0028]

The transmitting signal of GSM 850 or GSM 900 is sent to the antenna via the switch 560, part thereof is leaked to the terminal 510e. The leaked high-frequency signal is cut by the multiband diplexer circuit, thereby preventing it from flowing into RF-IC350 comprising a low-noise amplifier. The receiving signal of GSM850 or GSM900 from the antenna is deprived of spurious components (noises) such as sideband waves, etc. by the bandpass filter, and input into RF-IC350 as an impedance-changed balanced signal. Accordingly, the communications quality of mobile phones is not deteriorated. The circuit block shown in Fig. 5 teaches that the multiband diplexer circuit can be applicable to triple-band mobile phones of GSM850 / DCS1800 / PCS or GSM900 / DCS1800 / PCS, or the like.

[0029]

In the present invention, transmission lines and capacitors constituting phase shifter, switches and bandpass filters may be mounted on circuit substrates as chip parts, but may be formed as a sintered laminate (made of dielectric ceramic materials) produced by printing a conductive paste of a low-resistivity material such as Ag, Cu, etc. on a green sheet to form a predetermined electrode pattern, and integrally laminating pluralities of green sheets and sintering them.

Diodes, FETs and band filters in SAW filters are mounted on the ceramic substrates sinterable at low temperatures, and, accordingly, at that time they are preferably in a bare state and may be sealed with a resin or tube, they can be preferably made small. Thus, the multiband diplexer circuit can be preferably made small by forming in a laminate of ceramic substrates. Of course, other switches, amplifiers, etc. can be mounted to the laminate substrate.

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The dielectric materials sinterable at low temperatures, may be, for instance, materials comprising  $\text{Al}_2\text{O}_3$  as a main component, and at least one selected from the group consisting of  $\text{SiO}_2$ ,  $\text{SrO}$ ,  $\text{CaO}$ ,  $\text{PbO}$ ,  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  as an additional component, or comprising  $\text{Al}_2\text{O}_3$  as a main component, and  
5 at least one selected from the group consisting of  $\text{MgO}$ ,  $\text{SiO}_2$  and  $\text{GdO}$  as an additional component. Also, using an HTCC (high-temperature cofired ceramics) technology, transmission lines, etc. may be formed by high-melting-point metals such as tungsten, molybdenum, etc. on  $\text{Al}_2\text{O}_3$  ceramic substrates.

10 [0030]

In the embodiments mentioned above, detailed explanation on the unbalanced-balanced multiband diplexer circuit is made for easy description. The effects of the present invention is not changed even though the terminal P1 is changed to [an unbalanced] a balanced port as  
15 well as the terminal P2 is changed to [a balanced port] an unbalanced port, and a balanced-unbalanced multiband diplexer circuit is also within the technical scope of the present invention. The balanced-unbalanced multiband diplexer circuit as such is used in the transmitting circuit side in the mobile phones.

20 Although the embodiments of the present invention explain about the multiband diplexer circuit in an application thereof to two different access systems, it is possible either to change the switch in the diplexer circuit to a SP3T switch or to allow the multiband diplexer circuit to correspond to three or more of different access systems based on the  
25 technical idea of the present invention.

[0031]

**Effects of the invention**

According to the present invention, it is possible to provide the

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unbalanced-balanced multiband diplexer circuit which suppresses increase  
in insertion loss, and in communications or access systems utilizing  
extremely close frequency bands, it permits high-frequency signals in the  
operated communications or access systems to pass while cutting  
5 high-frequency signals in the other communications or access system.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a block diagram showing a multiband diplexer circuit of  
one embodiment of the present invention;

10 Fig. 2 is a block diagram showing a multiband diplexer circuit of  
another embodiment of the present invention;

Fig. 3 is a block diagram showing a multiband diplexer circuit of  
still another embodiment of the present invention;

Fig. 4 is a block diagram showing a multiband diplexer circuit of  
15 still another embodiment of the present invention;

Fig. 5 is a block diagram showing a high-frequency circuit for  
multiband mobile phones, which comprises a multiband diplexer circuit of  
the present invention;

Fig. 6 is a block diagram showing an SP5T switch used in the  
20 multiband mobile phone;

Fig. 7 is a block diagram showing a conventional two-frequency  
diplexer;

Fig. 8 is a block diagram showing a high-frequency circuit for  
multiband mobile phones comprising a conventional two-frequency  
25 diplexer circuit;

Fig. 9 is an equivalent circuit of the switch used in the multiband  
diplexer circuit of the present invention;

Fig. 10 is another equivalent circuit of the switch used in the

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multiband diplexer circuit of the present invention;

Fig. 11 is still another equivalent circuit of the switch used in the multiband diplexer circuit of the present invention; and

Fig. 12 is still another equivalent circuit of the switch used in the  
5 multiband diplexer circuit of the present invention.

**Explanation of symbols and numerals**

**1: Multiband Diplexer Circuit**

- 10 10a, 10b, 10c, 264, 310, 560, 570 and 580: Switch;  
20a, 20b, 220, 240, 230, 250, 251, 252, 253, 280 and 290: Bandpass Filter;  
40a, 40b, 50a, 50b, 60a, 60b, 70a, 70b, 254, 255, 256, 257, 258, 259, 260  
and 261: Phase Shifter;  
200 and 267: Oscillator;  
15 210: Frequency Multiplier;  
250a, 250b, 265 and 266: Amplifier Circuit; and  
268: Mixer Circuit.

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## ABSTRACT

### Problems to be solved:

To provide an unbalanced-balanced multiband diplexer circuit with  
5 suppressed increase in insertion loss.

### Solution:

A multiband diplexer circuit comprising, a single-pole-dual-through  
switch, a first unbalanced-input-balanced-output bandpass filter connected  
to a first output port of the first switch, a second  
10 unbalanced-input-balanced-output bandpass filter connected to a second  
output port of the switch, a second dual-pole-single-through switch  
connected to one of balanced output ports of the first bandpass filter and  
one of balanced output ports of the second bandpass filter, a third  
dual-pole-single-through switch connected to the other of balanced output  
15 ports of the first bandpass filter and the other of balanced output ports of  
the second pass band filter, the first to third high-frequency switches being  
switched depending on a passing high-frequency signal, whereby an  
unbalanced high-frequency signal input into the first switch is output from  
the output ports of the second and third switches as a balanced high  
20 frequency signal.

### Selected Drawings:

Fig. 1

Drawings

Fig. 1

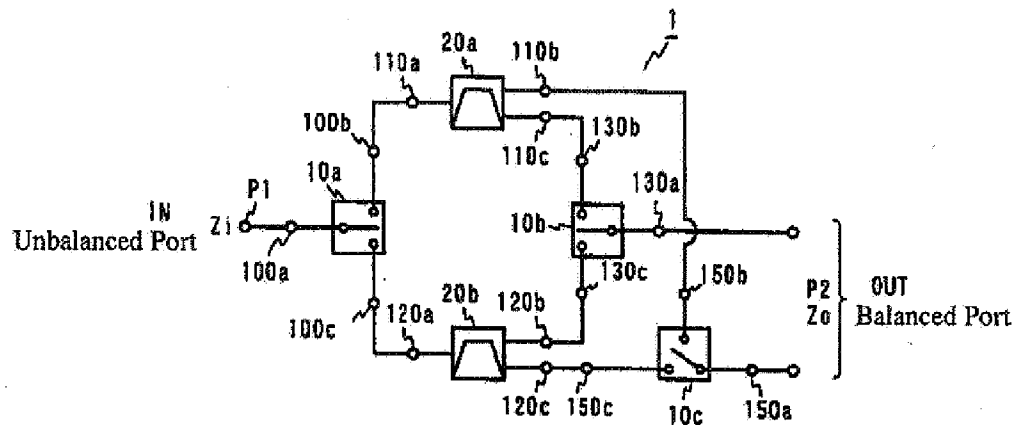


Fig. 2

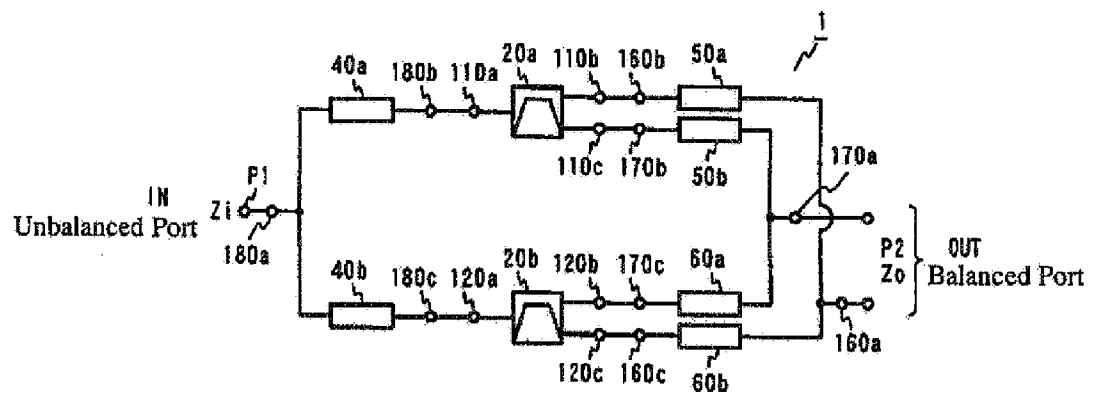


Fig. 3

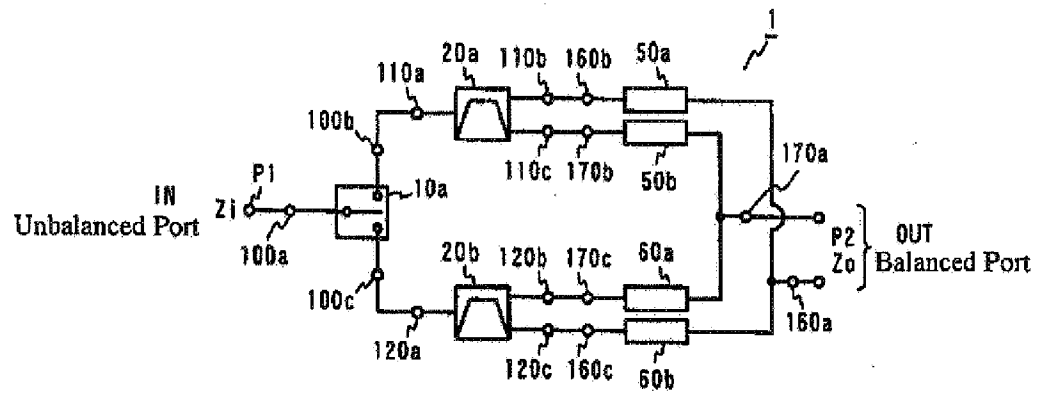


Fig. 4

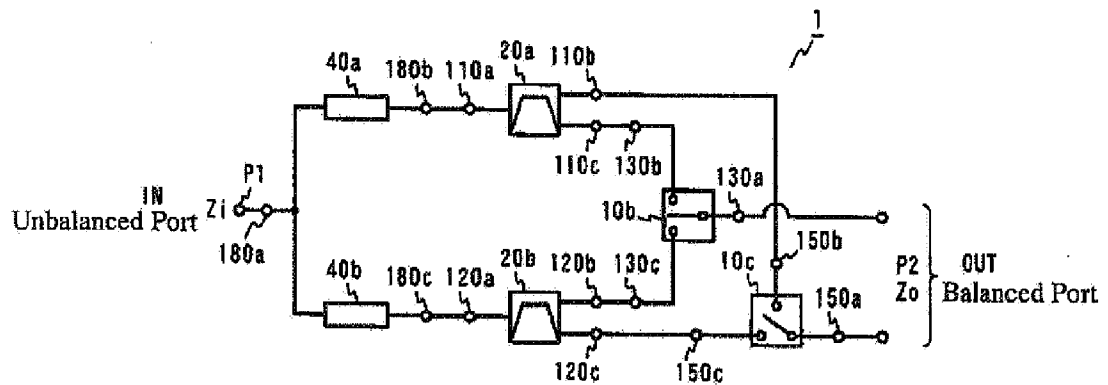




Fig. 5

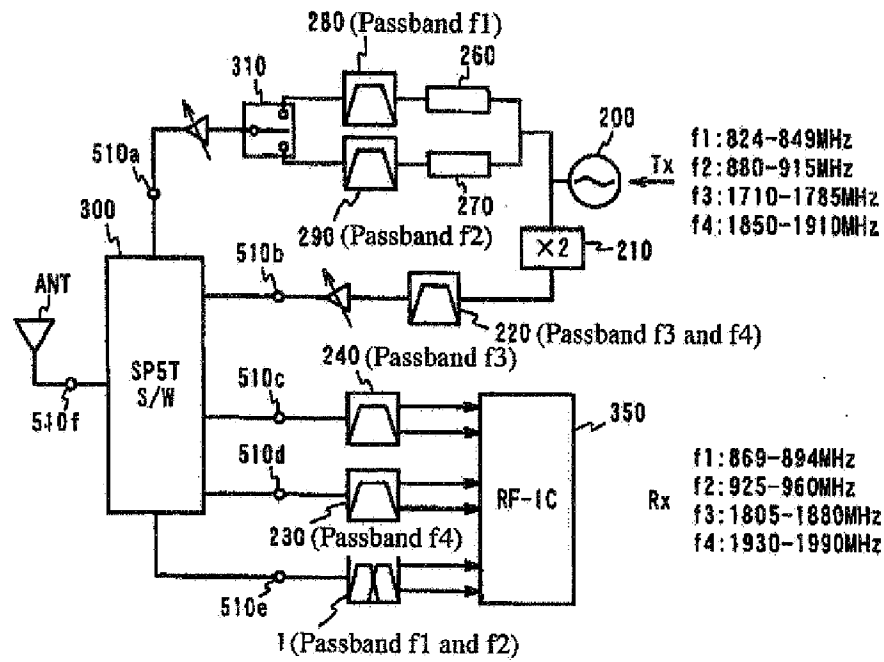


Fig. 6

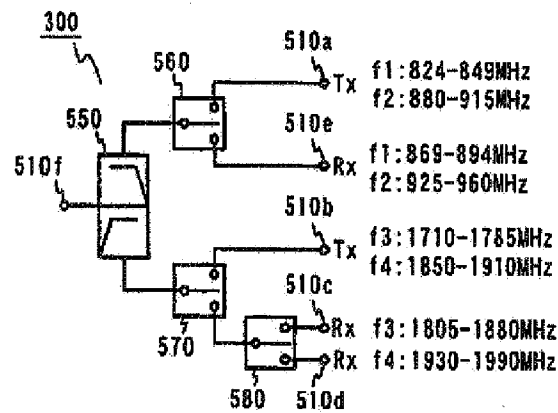


Fig. 7

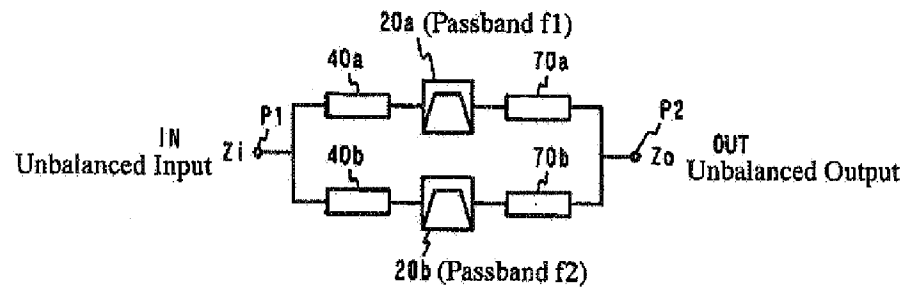


Fig. 8

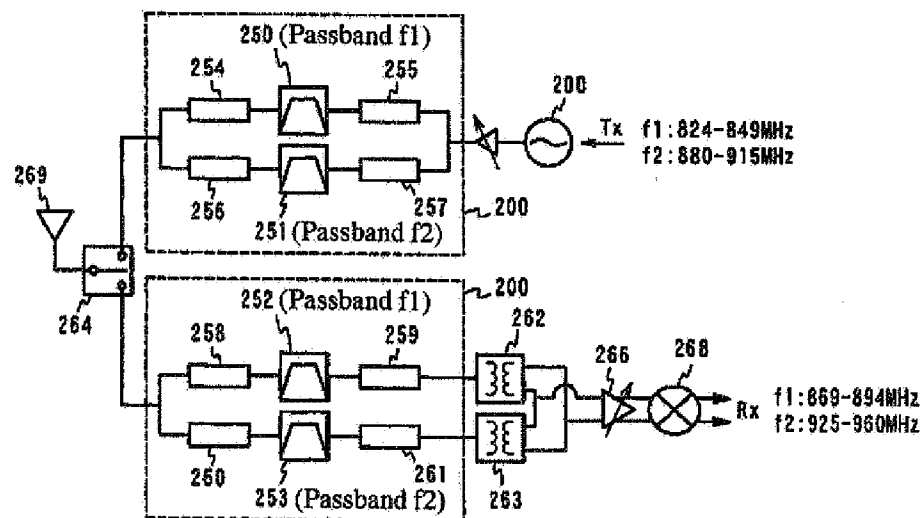


Fig. 9

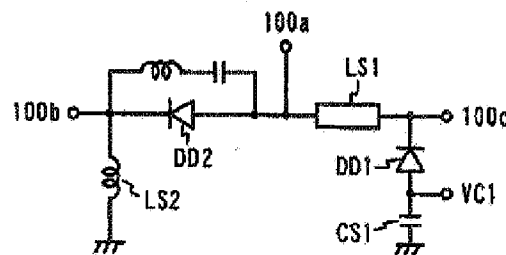


Fig. 10

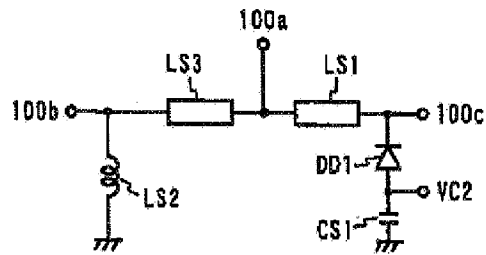


Fig. 11

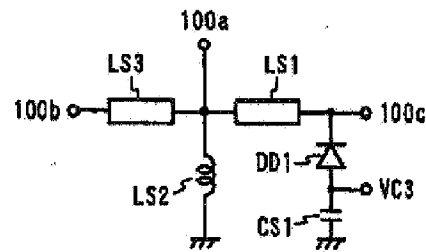


Fig. 12

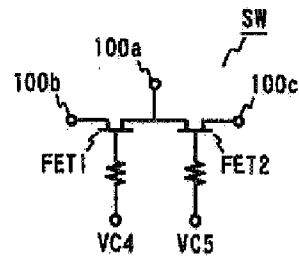


Fig. 13

